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Report of the National Marine Fisheries Service Southeast Fisheries Center, Miami Laboratory, Fiscal Years 1970 and 1971

ANN WEEKS and ALBERT C. JONES

SEATTLE, WA.
July 1972

U.S. DEPARTMENT OF COMMERCE
Peter G. Peterson, Secretary
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator
NATIONAL MARINE FISHERIES SERVICE
Philip M. Roedel, Director

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Foreword

This report of the Tropical Atlantic Biological Laboratory for Fiscal Years 1970 and 1971 (July 1, 1969 through June 30, 1971) is an attempt to summarize the research and related activities of the biologists, oceanographers, and supporting staff members who work at the National Marine Fisheries Service (NMFS) laboratory in Miami, Florida[1]. In early 1970, a reorganization of the Bureau of Commercial Fisheries (then an agency of the Department of the Interior) took place, which had a decided effect on field offices and laboratories. In October 1970, an even more fundamental restructuring of programs followed the establishment of the National Oceanic and Atmospheric Administration, under the Department of Commerce. The National Marine Fisheries Service was formed in an amalgamation of the former BCF and the marine fish programs formerly administered by the Bureau of Sport Fisheries, and the new Service placed under the direction of NOAA. The 2-year period covered by this report has been a satisfying one. Tuna-oriented programs instituted several years ago have borne fruit. Significant advances have been made in other existing programs and new ones have been established. High productivity, as measured by the publication of scientific papers, has been maintained in the face of reorienting laboratory programs to new challenges.

A fishery research laboratory has a number of responsibilities — a primary reponsibility for developing an understanding of fishery resources; a responsibility to the scientific community for the highest possible level of productivity and competence; a responsibility to the public for efficient use of funds for research; and a responsibility to its staff members for provision of the most stimulating work environment and the opportunity for career development. The extent to which these varied responsibilities are met determines the relative worth of the unit and the significance of its contribution to the national science program. We offer the following summary with the belief that our accomplishments in 1969-1971 were better than average, and with a commitment to continue effective research in the future.

CARL J. SINDERMANN
Director, Tropical Atlantic
Biological Laboratory[2]

[1] In July 1971 the name of the Tropical Atlantic Biological Laboratory was changed to Southeast Fisheries Center, Miami Laboratory.
[2] Now Director, National Marine Fisheries Service North Atlantic Coastal Fisheries Center, Highlands, NJ 07732.

REPORT OF THE NATIONAL MARINE FISHERIES SERVICE SOUTHEAST FISHERIES CENTER, MIAMI LABORATORY, FISCAL YEARS 1970 AND 1971[3]

by

ANN WEEKS[4]

and

ALBERT C. JONES

Abstract

The research program of the National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory (U.S. Department of Commerce, National Oceanic and Atmospheric Administration), Miami, FL, is described. Progress in investigations of the tropical Atlantic Ocean during Fiscal Years 1970 and 1971 is reviewed.

Introduction

The period was a crucial one for the Tropical Atlantic Biological Laboratory (TABL) (Fig. 1), as it was for many other NMFS laboratories. It was a time of intense re-examination of goals to be reached, a candid assessment of achievements and potentials, and — finally — a general reorientation of the research effort toward a greater contribution to the development and expansion of commercial and recreational fisheries in the southeastern region of the United States. By and large, TABL's course shifted gradually from fishery projects in distant waters to "closer to home" investigations.

TABL continued in the vanguard of those organizations engaged in a synchronized effort to develop tuna fisheries in the tropical Atlantic, yet establish and maintain conservation measures designed to preserve a healthy and profitable balance of the tuna stocks. Perhaps the most dramatic and far-reaching result of this concerted effort was the establishment, early in 1969, of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The organization was activated in December 1969, when its first meeting was held in Rome. Present were delegates from Brazil, Canada, France, Ghana, Japan, Morocco, Portugal, South Africa, Spain, and the United States. TABL's Director served as scientific adviser to the U.S. delegation and as a member of the Working Committee on Programs. Essential to the meeting was a series of documents prepared by TABL personnel, which presented facts and figures on the Atlantic tuna fisheries, painstakingly gathered and analyzed over the past 5 years.

Biological research at TABL continued to emphasize investigations of the eggs, larvae, and juveniles of tunas and tunalike fishes, but — in keeping with the restructured NMFS policy — increased its efforts to monitor and assess the populations of other species important to U.S. fishermen. Altogether some 50 species were reared from egg to juvenile stages, many for the first time. Twenty of these were commercially important fishes sought by fishermen and available in waters off the southeastern United States. The experimental rearing techniques used appear to be adaptable to many other species of marine fish.

Oceanographic research included participation in several interagency projects. One of these was the

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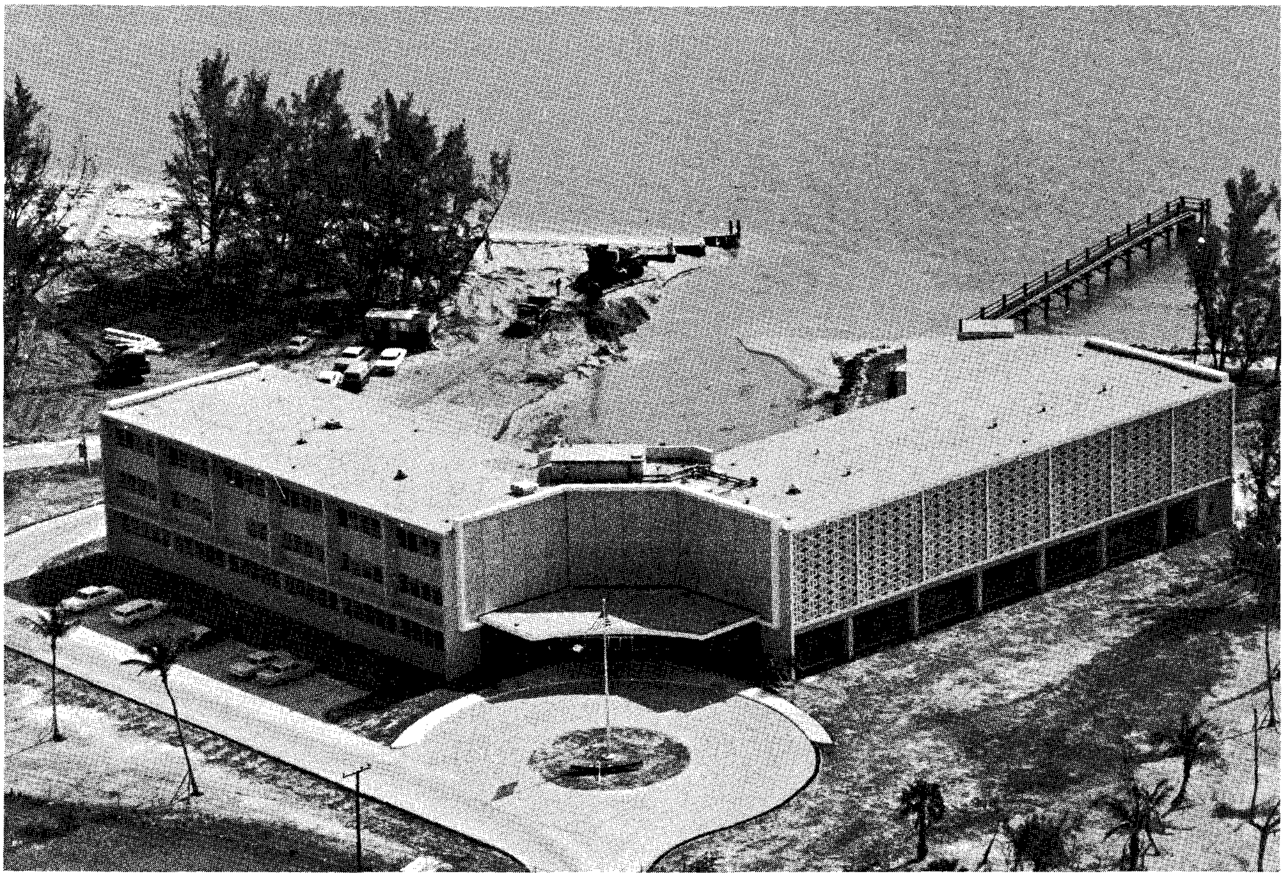

Figure 1. — The Southeast Fisheries Center, Miami Laboratory (formerly the Tropical Atlantic Biological Laboratory) is built on the shore of the Atlantic Ocean, at Virginia Key, Miami, Florida. The pier seen at top right is close to the Bear Cut Bridge; Bear Cut connects Biscayne Bay with the Atlantic Ocean.

Barbados Oceanographic and Meteorological Experiment (BOMEX), a multiship investigation of air-sea interaction over 90,000 square miles of the tropical Atlantic, which used the services of seven members of the staff for 2 months aboard the RV *Undaunted.* Another project called EGMEX was a collaborative investigation of the "loop" current in the eastern Gulf of Mexico (hence the acronym), carried out in conjunction with the U.S. Coast Guard and the Florida State University System Institute of Oceanography. A third project entailed the plotting and contouring of oceanographic data for the Joint Investigation of the Southeastern Tropical Atlantic (JISETA) Atlas. TABL oceanographers also were involved with several other Federal agencies in plans for monitoring oceanic features through use of orbiting satellites and aircraft.

Though established only a few months before the period covered in this report, the Calico Scallop Biology program made excellent progress. A number of cruises were completed to the calico scallop grounds off Cape Kennedy, Florida, and a broad and varied investigation of the life cycle and environmental needs of the species is well underway. Buoys to mark study sites were emplaced; TABL divers installed oceanographic sensing devices underwater, and positioned enclosures and cages on the ocean floor (to confine marked scallops for growth studies); spat traps and monitoring devices set in the water column provided scientists with abundant quantities of newly set scallops; and numerous scallops were laboratory-reared from eggs through juvenile stages. TABL will continue to work with other NMFS laboratories to provide scallop fishermen with the most up-to-date information possible on all facets of the developing fishery. Prospects appear favorable for growth and expansion of the fishery.

The production of scientific literature by the TABL staff was outstanding during the biennium — 83 papers were published, and another 30 were in press at the close of FY 1971.

Research Programs

Despite the reorientation of research effort, the essential structure of most of the TABL programs continued along the lines drawn in 1968 (Weeks, 1970[5]), with strong emphasis on tunas of the tropical Atlantic Ocean. Evolution in the scope and direction of the separate programs was not abrupt, but came about gradually. A major change took place in February 1970, however, when the RV *Undaunted* was retired from NMFS service and transferred to the National Science Foundation. The deactivation of the ship and the consequent diversion of funds enabled the laboratory to expand several ongoing investigations and initiate new ones. A second change — in June 1970 — resulted in the termination of the taxonomy program.

The following research programs were in effect during the biennium. Their objectives were:

1. *Tuna Fishery Biology:* Investigations were centered on estimation of recruitment, growth, and mortality in order to predict the harvestable yield of Atlantic tunas, reaction of tunas to the environment, identification of stocks and their distribution, and food and feeding habits. Subprojects concentrated on albacore and bigeye, blackfin, bluefin, yellowfin, and skipjack tunas.

2. *Developmental Biology of Tunas:* The program consolidated several distinct entities, all designed around an accelerated effort to understand the biology of the young of Atlantic tunas and other pelagic fishes. One phase of the program concentrated on studies of the distribution and abundance of tuna larvae found in the tropical Atlantic since investigations began in 1963; another phase was devoted to hatching tuna eggs and rearing the larvae; and a third phase involved determination of the reproduction and fecundity of tunas. The expertise and techniques developed by the biologists working in these specialized areas allowed quick acceptance of duties concerned with the new national program in assessing the marine resources available to the United States. This new program has been termed Marine Resources Monitoring, Assessment, and Prediction (MARMAP).

3. *Fishery Oceanography.* Fishery oceanography studies sought to define the effects of the environment on the abundance and availability of fish stocks and to develop predictive models that would enable the most effective use to be made of living resources. Like the above program, research in Fishery Oceanography was previously concentrated on understanding the environmental requirements of tunas, but was expanded to include environmental studies of other fishes in response to a need dictated by the development of the above mentioned national program for studying all fishery resources of interest to the United States.

4. *Calico Scallops.* A basic understanding of the stocks of the calico scallop estimated to occupy 1,200 square miles off eastern Florida was the goal of research studies in this program. Studies involved determinations of time of spawning, larval development, time and space variations in spat setting, identification of the stocks and estimation of the annual growth, recruitment, and mortality rates. Such information may make possible year-to-year predictions of distribution and abundance of scallops in the future.

5. *Taxonomy of Clupeoid Fishes.* This program studied the systematics of clupeoid fishes (herrings, sardines, and anchovies) and maintained the TABL reference collection of marine fishes. The program was terminated in early 1970.

Progress in Research

Participation by the U.S. fleet in tuna fishing in the eastern tropical Atlantic has expanded dramatically, and increases in catches have been substantial during the past 4 years (Fig. 2). When U.S. purse seiners entered the fishery in 1967, three vessels caught 1,600 tons of tuna (about 75% yellowfin tuna); in 1969, totals had climbed to 21 ships and a catch of just under 25,000 tons (valued at over $10 million). In 1970, 22 seiners caught about 22,000 tons of tuna which included more than 50% skipjack tuna; in the 1969 landings 85% of the catch consisted of the more valuable yellowfin tuna.

Tuna fisheries elsewhere in the Atlantic also have increased since 1968 (Fig. 3). A record 250 longliners (from Nationalist China, South Korea, and Japan) fished for deep-swimming tunas (mostly albacore and yellowfin tuna) in the Atlantic in 1969. This effort represented a 100-vessel addition to the

[5] See "List of Publications" for detailed information on scientific papers by TABL personnel.

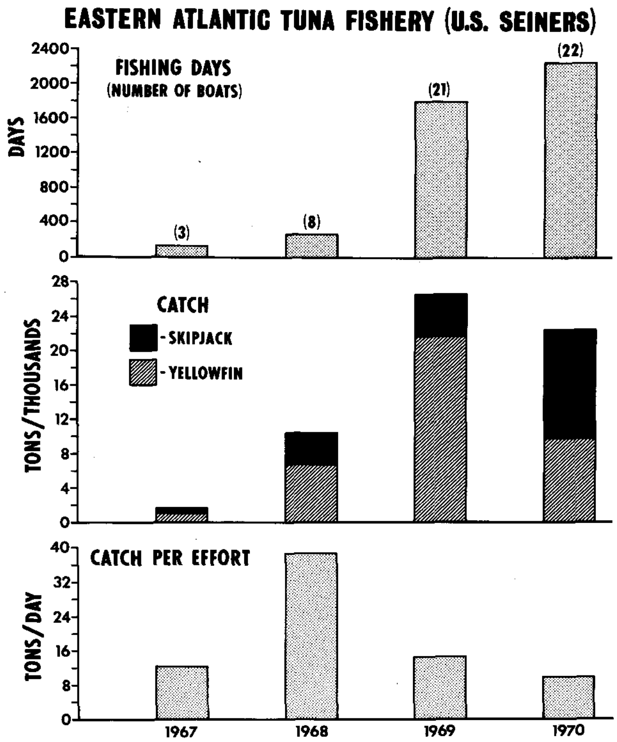

Figure 2. — The catch of Atlantic tunas by U.S. purse seiners in 1967, 1968, 1969, and 1970.

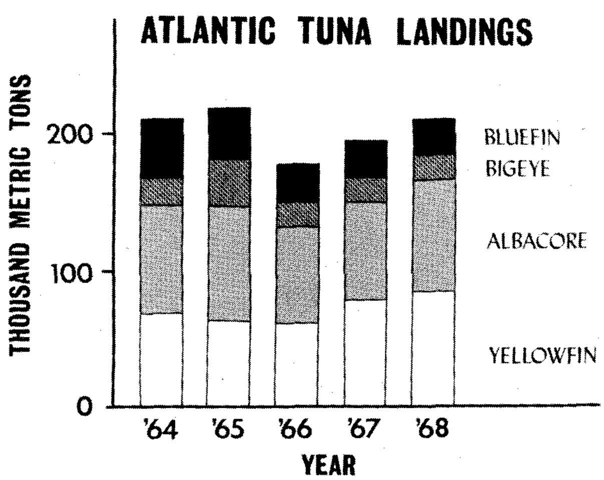

Figure 3. — Landings of Atlantic tunas by species, 1964 through 1968.

peak year (1965) of the Japanese longline fleet. In 1970 between 250 and 300 boats operated. The increase in longlining was mostly by Koreans and Nationalist Chinese; the Japanese fished at the relatively low level of about 30 million hooks annually. Also, fishing at the surface for bluefin and skipjack tunas off New England and the mid-Atlantic States was unexpectedly profitable (about 5,000 tons) during 1970.

TUNA FISHERY BIOLOGY

As a consequence of the growth of the Atlantic tuna fishery, a matching growth occurred in the scientific investigation of the resource by various international bodies and, in turn, by TABL in 1970 and 1971. A considerable amount of the work done by TABL's Tuna Fishery Biology program formed part of the groundwork for the emerging ICCAT, which is expected to have a profound effect on tuna fisheries in the Atlantic. As a prelude to the formation of the Commission, the first working party meeting of tuna experts — under the auspices of the Food and Agriculture Organization of the United Nations (FAO) — was held at TABL in 1968. Soon afterward, FAO issued a report on the meetings in its Fisheries Report No. 61, which assessed the status of Atlantic and Indian Ocean tuna stocks. The director of TABL served as scientific adviser to the U.S. delegation at the first meeting of ICCAT at Rome in December 1969, with delegates from 10 nations in attendance. The chief of the Tuna Fishery Biology program devoted part of his time to coordinating arrangements for the November 1970 ICCAT Stock Assessment Sub-Committee meeting held at Madrid. Discussed at the meeting were TABL's analyses of catch records for various kinds of Atlantic tuna (Fig. 4). These analyses show — on the basis of measurements of the lengths of 55,000 yellowfin tuna — that bait-boat fisheries in the tropical Atlantic take mostly 1-year-old yellowfin tuna, purse-seine fisheries take mostly fish over 2 years old, and longliners catch fish over 3 years old. Preliminary estimates of maximum yield per recruit measured against probable natural and fishing mortality rates lend weight to the belief that 2 years is the most logical age at which yellowfin tuna should be caught. Yellowfin tuna in this 2-year age group average 100 cm (39 in.) in length and 22 kg (48 lb.) in weight.

The Assistant Laboratory Director of TABL was appointed Convenor of the ICCAT Sub-Committee on Stock Identification in November 1970. A tagging program for yellowfin tuna was agreed on by the Sub-Committee at the early-1971 meeting and arrangements were made for U.S. scientists to tag tunas from French and Portuguese (Angola) boats in 1971 and 1972. TABL biologists also tagged bluefin tuna in the northwest Atlantic during the summer of 1971 in cooperation with Woods Hole and Canadian scientists, to test the relative effectiveness of two types of tuna tags.

Two TABL scientists — the assistant director and a biologist from the Tuna Fishery Biology program — served as scientific party chiefs on 3-week research cruises for the Caribbean Research Development Program (Exploratory Fishing) of FAO. The cruises, both on the research vessel *Calamar*, took place in February and March 1970 and were part of an extensive investigation of tuna and baitfish resources present in waters around the Lesser Antilles Islands. Tuna schools were fished by pole-and-line on the cruises. Abundant schools of tuna (primarily skipjack) were sighted in the same areas where, in 1968 and 1969, the TABL vessels *Geronimo* and *Undaunted* had encountered numerous schools of yellowfin and skipjack tunas (Fig. 5).

Albacore in the Atlantic were investigated intensively. A summary report prepared on the population dynamics of this species indicates that the two stocks of albacore in the Atlantic (North and South) have not declined to any great extent and in some cases could probably provide increased yields. The North Atlantic stock contributes young albacore (1-5 years) to the Bay of Biscay surface fishery and older fish (4-11 years) to the central and western North Atlantic longline fishery. The ages of the fish were estimated using length frequencies. Based on the most likely total mortality rate of 62% per year, approximately 9 million 3-year-old albacore, the age at which they are fully recruited, are believed to be available to the Bay of Biscay surface fishery each year. Less is known about albacore in the South Atlantic where no surface fishery exists for small fish, as in the Bay of Biscay. An untapped resource of small albacore may exist in the South Atlantic but it is also possible that recruitment to the adult stock in the South Atlantic is from the Indian Ocean.

As a result of the transfer of the population dynamics work to La Jolla, program personnel spent considerable time redesigning and reorienting goals toward biological studies on tunas and billfishes. The following studies are now underway.

A sampling program was begun in 1969 with the cooperation of the Inter-American Tropical Tuna Commission (IATTC), wherein a biologist assigned to the Tuna Fishery Biology program regularly visits tuna canneries in Puerto Rico. The main objective of the study is to collect albacore gonads to determine spawning areas and seasons and to confirm the belief that albacore found in the North Atlantic belong to a different stock from those of the South Atlantic. Also under analysis are length-frequency data for the albacore, which in time should permit predictions of sizes and locations of albacore stocks, and allow for estimates of maximum potential yields.

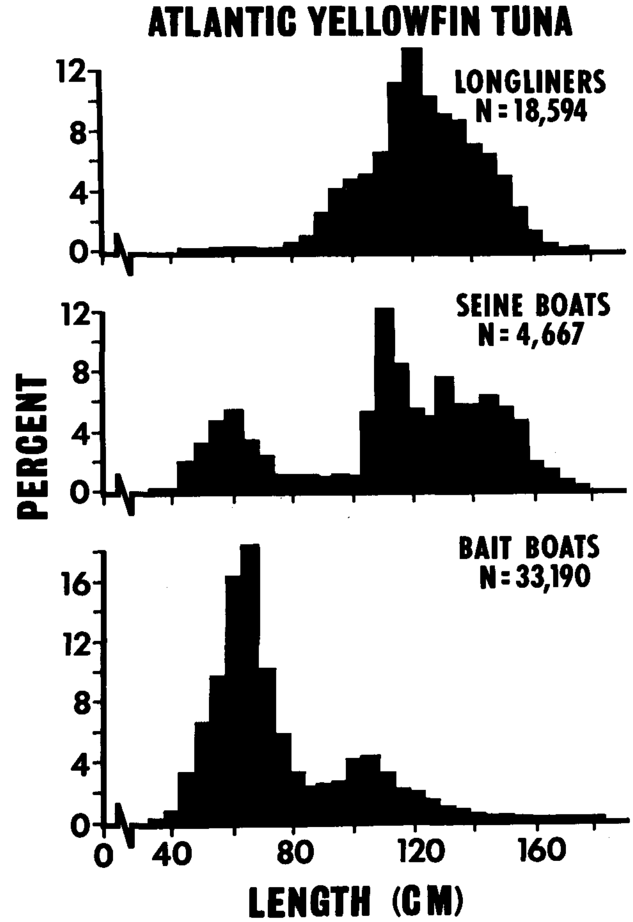

Figure 4. — Length-frequencies of Atlantic yellowfin tuna caught by longliners, seiners, and baitboats.

Distributional maps showing the seasonal distribution of tunas and billfishes in the Atlantic are nearing completion. Computer contouring techniques are used to display relative seasonal concentrations of fish on the basis of longline catch records. Maps have been completed for all the billfish and most of the tunas.

Also initiated during 1970 was a long-term study of bluefin tuna, in collaboration with investigators at the Woods Hole Oceanographic Institution

Figure 5. — Fishermen on the RV *Undaunted* bring aboard a large yellowfin tuna on a two-line rig. Photo was made on a research cruise in the Caribbean Sea.

(Mass.) and the NMFS Biological Laboratory at Oxford (Md.). The work concentrates on morphometrics, size frequencies, long and short migrations, population dynamics, and distribution of the species. Data collected over 20 years are under analysis; in preparation is a scientific paper covering all extant information concerning migrations of the bluefin tuna.

Also in cooperation with a scientist from Woods Hole, a study was completed on the migrations of white marlin and blue marlin in the Atlantic on the basis of tag returns and longline catch records. Apparently at least two and possibly three separate stocks of white marlin inhabit the North Atlantic. One stock migrates from off the northeast coast of the United States in fall, to the north coast of Venezuela in winter. In spring this stock begins its return migration through the Antilles and Bahamas and around Cuba. Another group apparently also winters off Venezuela, but in spring moves through the Yucatan Channel into the Gulf of Mexico to spend the summer. A separate population of white marlin exists in the South Atlantic, but apparently the stocks do not mix across the equator since no tag recoveries have been made in the South Atlantic, and longline catch records show low catch rates in equatorial regions throughout the year. There appear to be two populations of blue marlin also — one in the North Atlantic and one in the South Atlantic.

DEVELOPMENTAL BIOLOGY OF TUNAS

The proliferation of fisheries for tunas in the tropical Atlantic caused an upsurge in research to reach an understanding of the biological nature of the exploited tuna populations. Still not fully understood are exactly what environmental conditions sustain tuna populations and provide for continuously strong year classes. TABL scientists share the widely held opinion that year-class strength is determined in the earliest stages of the life of the fish. Much of the research, therefore, was directed toward striving to discover place, time, and quantity of spawning; identifying eggs, larvae, and juveniles among species; explaining the environmental tolerances of young fish; and reaching an understanding of the behavior and physiology of fishes in early stages. Basic biological knowledge of the adults was also sought, including factors related to age and growth, food and feeding habits, and fecundity.

Several years of work culminated in the completion of analyses of data gathered during some 5 years of research cruises, beginning with the EQUALANT cruises in the tropical Atlantic in 1963. Descriptions have now been compiled of the relative apparent abundances and distributions of tuna larvae in much of the tropical Atlantic, on the basis of data collected on more than 20 cruises by the vessels *Geronimo* and *Undaunted* in the northwestern Gulf of Guinea, off Sierra Leone, and in the Caribbean.

Larvae of the tropical tunas — yellowfin, bigeye, and skipjack — were widely distributed in the EQUALANT survey area, indicating that these species spawn over much of the Atlantic equatorial region. Young bluefin tuna and albacore — more temperate species — occurred rarely. The three tropical species were restricted to waters where surface temperatures were higher than 24°C. The tropical species also showed differences in their daily migrations in response to light. Skipjack tuna larvae migrated to the surface primarily at night, whereas larvae of yellowfin and bigeye tunas migrated to the surface primarily during the day. Frigate mackerel larvae (*Auxis* sp.) were considerably more abundant than tunas in the plankton samples. (Adult frigate mackerel are too small to be sought by fishermen, but are an important forage species for the larger tunas.) Little tunny larvae (*Euthynnus alletteratus*) were generally near shore, suggesting that this species probably does not spawn in the offshore areas.

Considerable attention was devoted to investigation of juvenile fishes (Fig. 6). Studies were completed on the seasonal distribution of juvenile scombrids in the waters near the Dry Tortugas, Florida. Because these fast-swimming fishes are generally difficult to collect, information on their distribution is scant. Program scientists sought and received assistance from National Park Service biologists engaged in banding terns in the Dry Tortugas, who often collected food items regurgitated by the birds. Among the food items thus collected were juvenile bluefin tuna, blackfin tuna, skipjack tuna, little tuna, and frigate or bullet mackerel. The size of fish in the samples suggested that bluefin tuna may spawn in the Dry Tortugas region in April and May, and blackfin tuna perhaps in March and April.

Studies of larval tunas longer than 3 mm have made it possible to identify all but two of the Atlantic species. Those that can now be identified in the larval stages are: albacore, bluefin tuna, little tunny, skipjack tuna, and yellowfin tuna. Those for which identification is still in doubt are the bigeye tuna (found in both the western and eastern Atlantic) and the blackfin tuna (found in the western Atlantic only), whose characteristics are seemingly so much alike that the larvae cannot so far be separated to species. The problem is under close study, as are means of identifying larval tunas measuring less than 3 mm.

Field tests were made of the "Bongo" plankton sampler, the standard collecting gear proposed for the national Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program. Replicate plankton samples were collected at towing speeds of 3, 4, 4.5, and 5 knots. At the higher speeds, the net extruded eggs and larvae and damaged larvae, which made identification difficult. It was recommended, therefore, that the "Bongo" net be towed no faster than 3 knots.

The program leader took part in several NMFS workshops in 1970 and 1971 to set up operation schedules for the MARMAP surveys and also conducted a 2-week course in identification of larval fish at TABL in May 1971. Scientists from seven NMFS laboratories attended the course.

Hatching and rearing studies continued to play an important part in the developmental biology program, after the initial successes (in 1968) in rearing tunas and clupeoids from eggs (Houde and Richards, 1969; Houde and Palko, 1969; and Weeks,

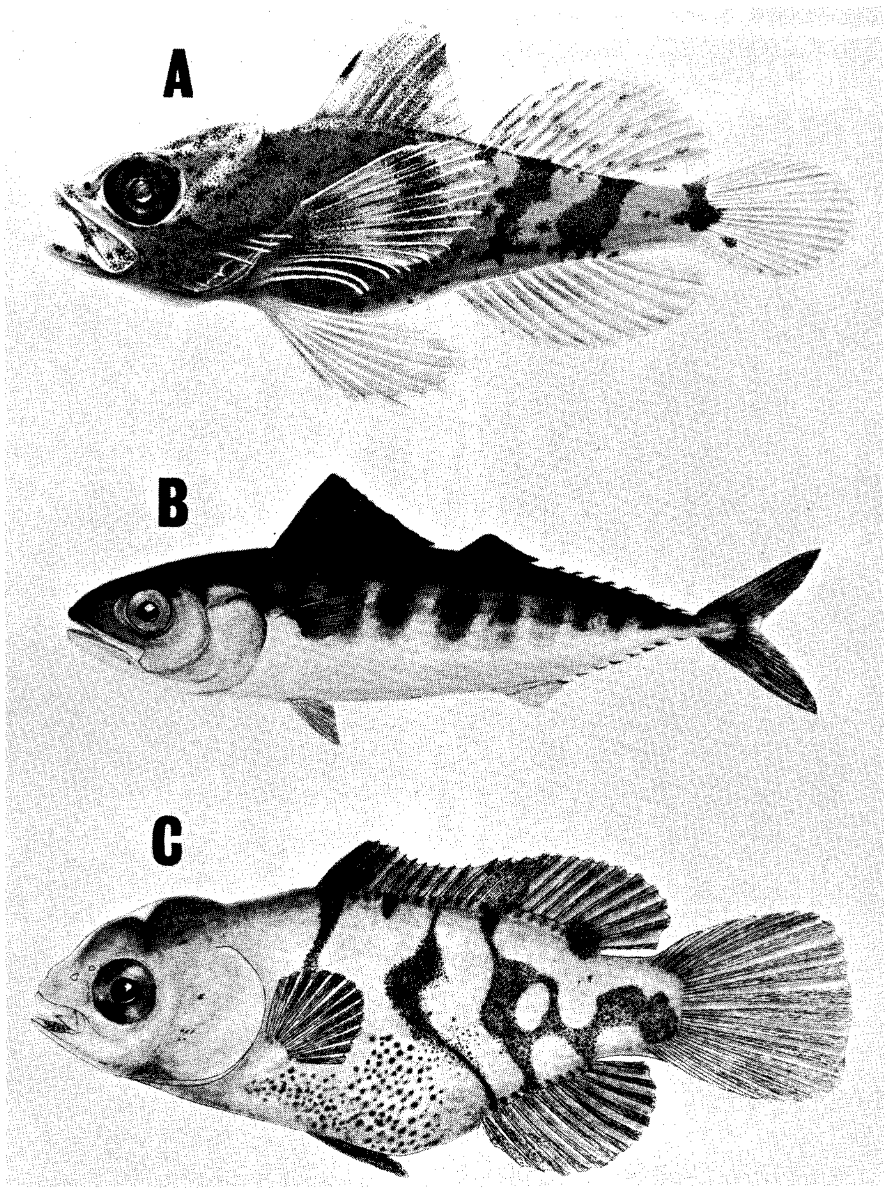

Figure 6. — Juvenile specimens of marine fish under study at TABL. Shown top to bottom are: a searobin (*Prionotus*), a tuna (*Thunnus*), and a hogfish (*Lachnolaimus*).

1970). In the past 2 years, 20 commercially important species were reared from egg through juvenile stages. Four of these were the scombrids *Auxis* (frigate or bullet mackerel), *Euthynnus alletteratus* (little tunny), *Scomber japonicus* (chub mackerel), and *Scomberomorus cavalla* (king mackerel). Others included anchovies, barracuda, flounders, herrings, mullets, porgies, soles, and sardines (Fig. 7). About 30 additional varieties of non-commercial fishes were cultivated successfully, from egg to juvenile. The early life histories of most of the laboratory-reared fishes heretofore were virtually unknown. Studies were begun of the temperature tolerances of some of these species (Fig. 8).

The rearing techniques developed at TABL undoubtedly will be of value to students of other marine fish and to aquaculturists. Interestingly, the best success in rearing marine fish larvae was obtained in tanks containing a bloom of the alga *Chlorella*, which was not eaten by the larvae but

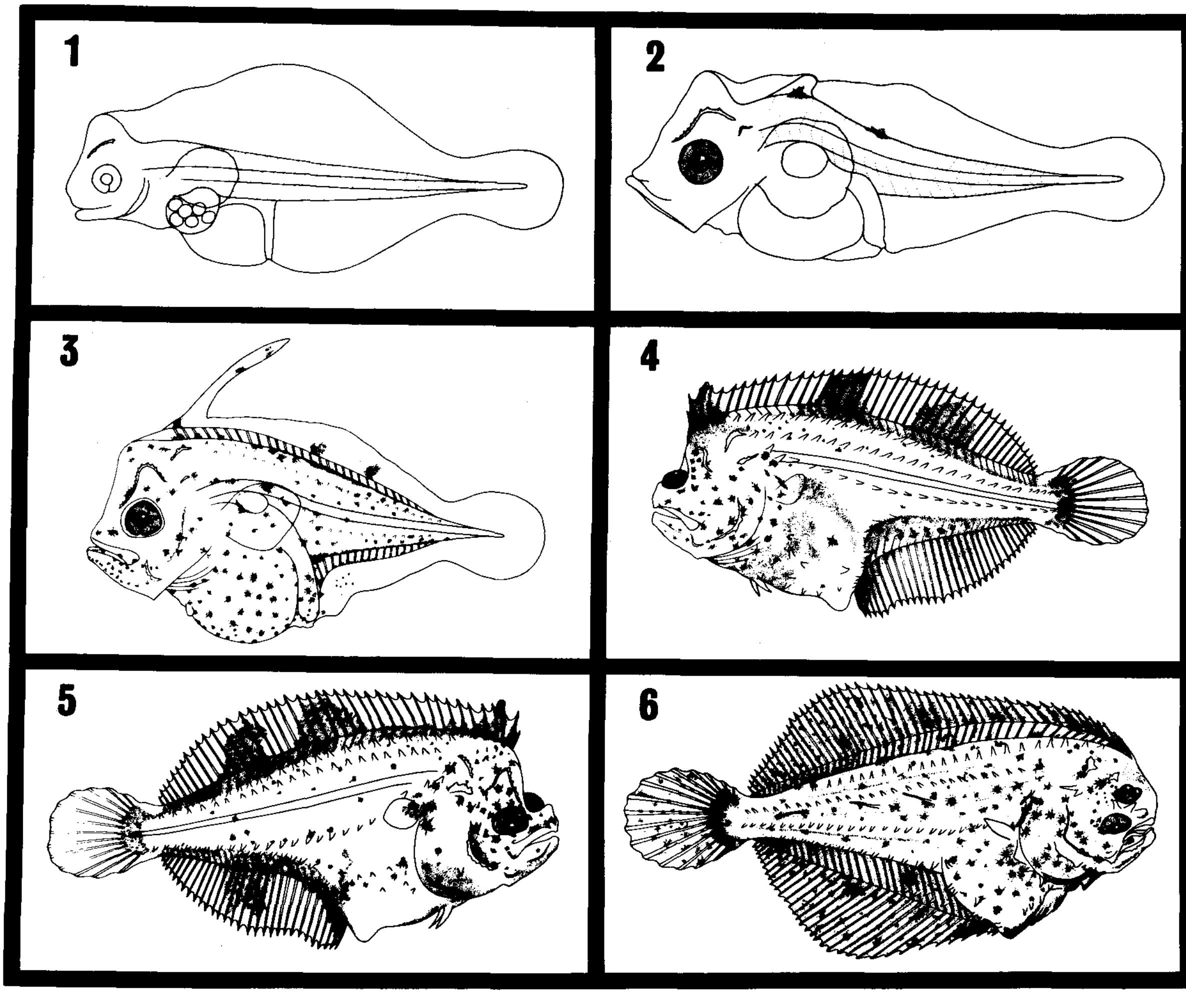

Figure 7. — Larval and juvenile stages of the lined sole *(Achirus lineatus)* reared at TABL from 1 day after hatching (#1 in photo) to 27 days after hatching (#6 in photo). Metamorphosis began in laboratory-reared larvae at 10 days after hatching (#3, 4, and 5 in photo); growth averaged 0.26 mm standard length per day, and lengths ranged from about 1.5 mm standard length at hatching to about 5 mm when specimens were 27 days old.

possibly acted to reduce the concentration of metabolites in the rearing tanks. The fish larvae fed on a variety of organisms including copepod nauplii, copepodites, and copepods. Larvae of the scaled sardine, *Harengula pensacolae,* and the bay anchovy, *Anchoa mitchilli,* grew fastest when the concentration of potential food organisms averaged 1,500 per liter.

Program researchers regularly collected zooplankton from the nearby Straits of Florida and devoted particular attention to studying the seasonal distribution of scombrids. For 2 successive years, larvae of bluefin tuna were observed in collections acquired by tows in May and June. Interesting, but no more than that, were the facts that a scarcity of bluefin tuna larvae (nine specimens) in tows of spring 1969 coincided with a poor sportfish catch of bluefin tuna in the western Bahamas, and that an abundance of the larvae in 1970 (68 specimens) coincided with a good catch by sportsfishermen in the Bahamas spring tournaments.

FISHERY OCEANOGRAPHY

Detailed studies of the physical, chemical, and biological oceanic environment are carried out under this program to correlate the distribution of marine fishes with time and space variations of the ocean environment, and to develop prediction systems for improving the ability to detect and locate concentrations of fish in commercial quantity.

A number of studies were completed during FY

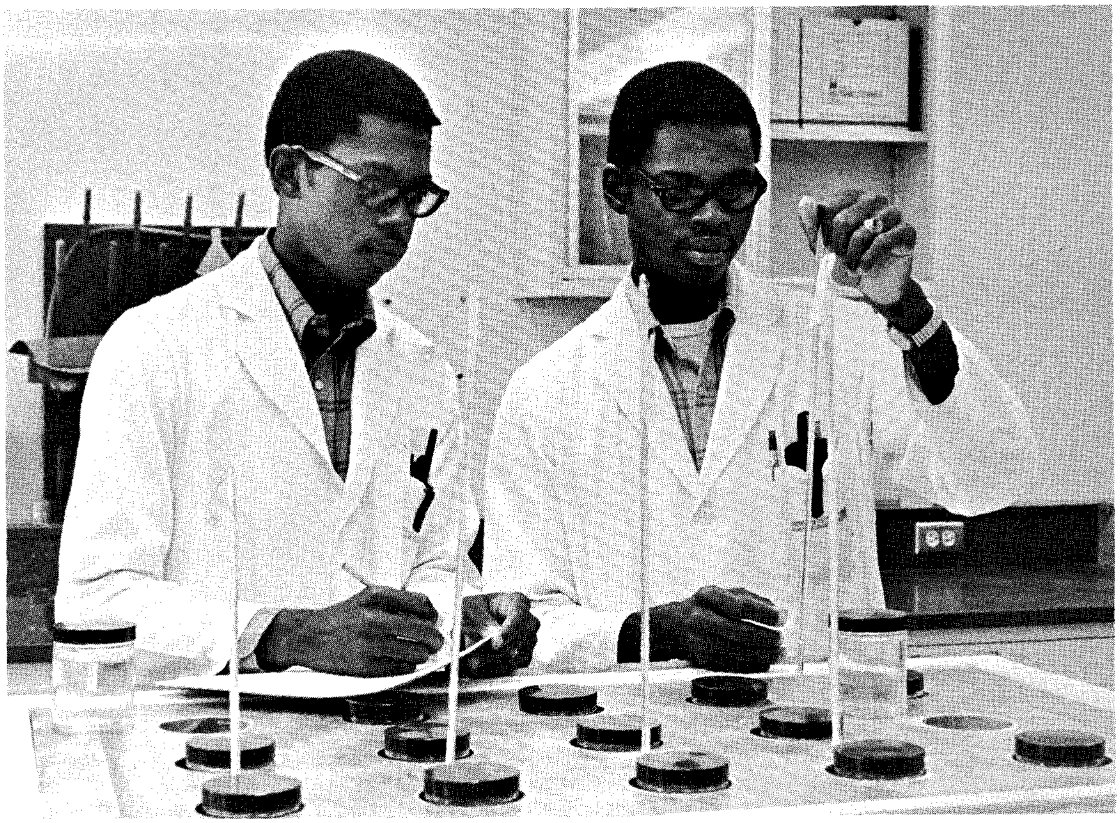

Figure 8. — Twin technicians work at the temperature-gradient block, which reveals temperature tolerances of eggs and larvae of fishes. Each vertical row of jars contains water of the same temperature — temperatures in the three horizontal rows of jars generally range from 20° to 35°C. Eggs and larvae are kept in the jars for various periods of time to determine optimum temperatures for survival, and temperature limits.

1970 and 1971: (1) a study of surface winds off the west coast of Africa designed to aid tuna fishermen in predicting areas and seasons suitable for purse-seine fishing; (2) a description of the seasonal changes in the surface oceanography of the tropical Atlantic Ocean (Fig. 9) and the effect of these changes on the lower food chain organisms; (3) a description of the ocean currents near the Lesser Antilles and the resulting downstream turbulence and enrichment; (4) a study of the transit time of a shallow layer of high salinity water from its origin (off Brazil) to the Island of São Tomé in the Gulf of Guinea; (5) oceanic features adjacent to the north-east "bulge" of Brazil; (6) a study of the distribution of wind-driven and current-induced upwelling in the Gulf of Guinea; and (7) methodological studies on interpolating oceanographic data, bibliography of zooplankton sampling devices, an *in situ* molecular oxygen profiler, enzyme clearing and staining of fishes, and measuring oceanic features from satellites.

Program personnel participated in investigations of the "loop current" in the eastern Gulf of Mexico. These cooperative studies, coordinated by the Florida State University System Institute of Oceanography, included routine oceanographic observations by vessels, U.S. Coast Guard overflights to measure sea-surface temperature with airborne radiation thermometers (ART), and drift-bottle releases for study of water currents.

The RV *Undaunted* completed a cruise in August 1969 to the southeastern Caribbean in support of the BOMEX operations in the region of Barbados. The *Undaunted* cruise was designed primarily to provide additional information on the relation between the distribution of surface-schooling tuna and their environment. Previous cruises in the area in the spring of the year had suggested a possible relation between schools of tuna and dynamic structures (eddies). During the summer cruise, however, eddies west of St. Vincent Island (West Indies) were poorly developed and only a few tuna

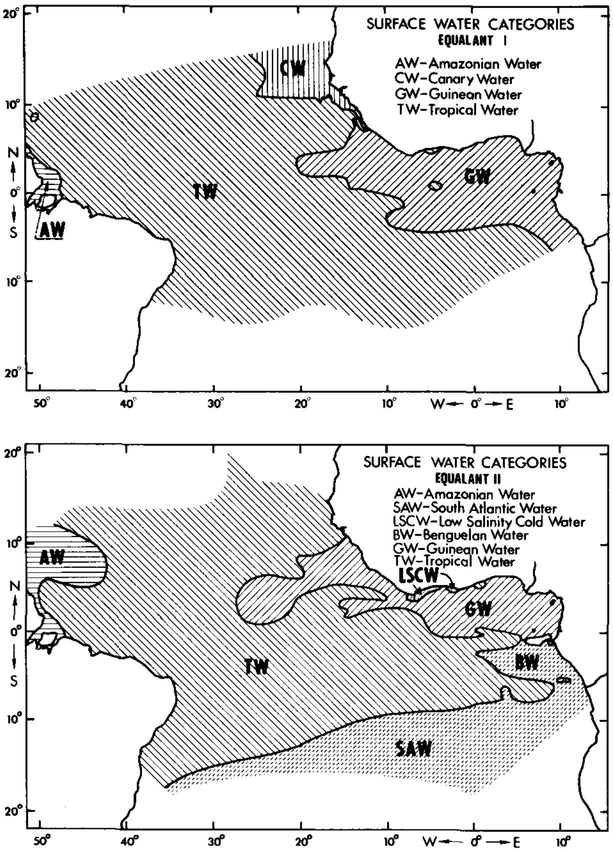

Figure 9. — Surface water categories measured during EQUALANT I (Feb. - March 1963) and EQUALANT II (July - Sept. 1963). Temperatures and salinities were measured at 10 m. The water categories are based on the criteria: AW, T > 24° C, S < 35‰; CW, T < 24° C, S > 35‰; GW, T > 24° C, S < 35‰; TW, T > 24° C, S > 35‰; SAW, T < 24° C, S > 35‰; ISCW, T < 24° C, S < 35‰; BW, T < 24° C, S > 35‰.

schools were sighted. It appears that tunas do not frequent this area during the summer season when eddies are poorly developed and forage is apparently not plentiful. Data collected included wind speed and direction, air temperature, dewpoint temperature, sea-surface temperature, infra-red sea-surface temperature, solar radiation in two radiation bands, phosphate-phosphorus, dissolved oxygen, zooplankton, chlorophyll and carbon-14 uptake.

An atlas is nearly completed based on data collected during the JISETA survey by the RV *Undaunted*, the *Rockaway* (USCG), and the RV *Goa* (Missão de Estudos Bioceanológicos e de Pescas de Angola). Data to be portrayed in the atlas will include temperature, salinity, oxygen, phosphate, zooplankton biomass, chlorophyll, carbon 14, tuna school distributions, and bird sightings.

Description of the distribution of water favorable for tuna fishing in the tropical Atlantic was begun by compiling data on monthly mean temperature (1966 to 1970) for the 0-, 100-, 200-, 300-, and 400-m surfaces. Special emphasis is being given to the Gulf of Mexico and the Gulf of Guinea, where the surface temperature data are being compiled at 15-day intervals.

Considerable time was devoted to studies involving the feasibility of monitoring the oceanic environment and acquiring broadscale data through satellites, high-flying aircraft, and buoys equipped with sophisticated instrumentation (Fig. 10). Some of these studies concentrated on detecting features of oceanic "fronts" from aboard the RV *Undaunted*, which was equipped to receive visible wavelength data from NASA and NOAA satellites. In other studies infrared data from satellites were received and used to detect thermal boundaries and water masses of different temperatures (Fig. 11). Dr. Miriam Sidran, an NSF-sponsored physicist appointed to a summer program at TABL, synthesized related data from a variety of agencies and other sources. Her report entitled "Satellite Remote Sensing of Oceanographic Indicators of Fish Populations" will be used to determine how satellite data presently available may be used to assess the abundance and distribution of fish populations.

Program scientists are active in a ship-of-opportunity program in cooperation with the U.S. Maritime Administration. This program, termed MARAD, involves the use of U.S. merchant ships as sampling platforms and Maritime Academy cadets from Kings Point, N.Y., as observers. The purpose of the program is to monitor major oceanic circulation patterns and current boundaries of the Caribbean Sea, Gulf of Mexico, and adjacent Atlantic areas where continuous sampling by oceanographic research vessels is not possible. Sampling presently consists of temperature versus depth observations along four selected routes (New York-eastern Caribbean, New York-Brazil, New Orleans-Brazil, New Orleans-Panama). A one-week training course in expendable bathythermograph (XBT) operation was given to 69 cadets at the Academy in January 1971. Shipping companies providing support to the program are Grace Lines and Moore-McCormack Lines (N.Y., N.Y.), Delta Lines, and Gulf and South American Steamship Company (New Orleans, La.). The Fishery Oceanography program worked closely with the Calico Scallop program, literally from the ocean

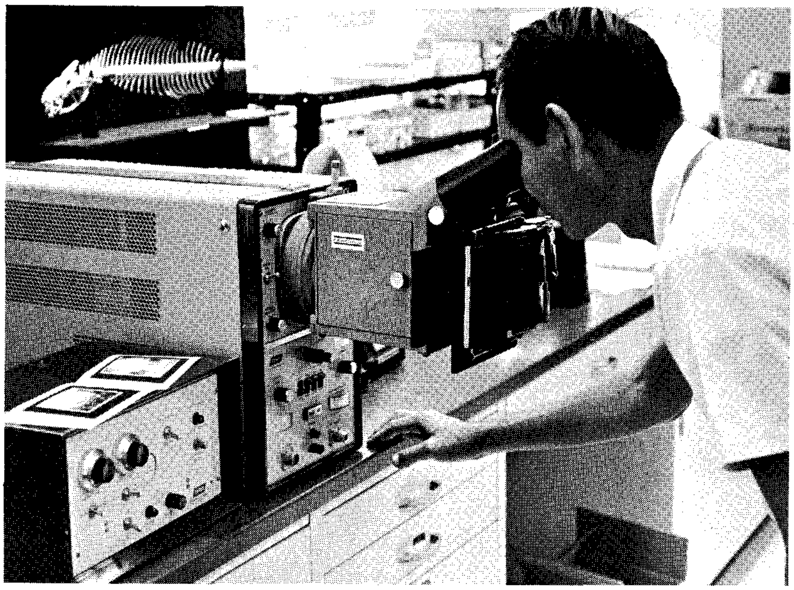

Figure 10. — A member of the Fishery Oceanography program monitors photos (received as television or infra-red images) on an APT (automatic picture transmission) receiver. Pictures are received from three or four different satellites as they pass within range, at the rate of one photograph every 2 minutes. The operation of the APT is identical to that of the now-familiar commercial television coverage of weather from satellites.

bottom to above the earth, in attempts to assess the oceanic environment of calico scallops off Cape Kennedy, Florida. This joint interdisciplinary study by oceanographers and biologists has proved fruitful in ascertaining the interaction between scallops and their environment. Program observers participated in ART flights by the U.S. Coast Guard and took consecutive infrared and color photographs to determine whether oceanographic features, such as upwelled water, internal waves, the edge of the Gulf Stream, and chlorophyll and suspended material in the water, could be detected from the air. Results were affirmative.

Chemical analyses and general procedures also are part of the responsibility of this program. Experiments concluded during the 2-year period involved the nitrate specific electrode in seawater.

In early tests removal of chloride ion interference by chemical pretreatment was not successful. Efforts are now directed toward removal by fractional crystallization and filtration, and preliminary techniques have been found favorable. Use of the oxygen-phosphate ratio as a quality control tool has been expanded with the establishment of a computer program to plot station profiles of that factor. Data from an entire cruise may be examined quickly, and suspect data usually can be detected almost immediately. The oxygen-phosphate ratio also has been studied as a potential indicator in water type studies. A report was published on results obtained through use of an *in situ* molecular oxygen profiler; another has been completed which describes the construction and operation of an ultraviolet sterilizer for large-volume aquariums.

Analysis of zooplankton collections made on many cruises in the tropical Atlantic Ocean continues. Some of the species that have been sorted, identified, and counted for estimates of percentage composition are: amphipods, chaetognaths, copepods, euphausiids, and shrimp. Data concerning carbon-14 uptake, phytoplankton pigments, and phytoplankton species for all cruises by TABL vessels have been prepared for automatic data processing. An annotated bibliography of zooplankton sampling devices was published.

CALICO SCALLOP BIOLOGY

The calico scallop, *Argopecten gibbus*, is fished commercially in the Atlantic Ocean off North Carolina and Florida, and in the northeastern Gulf of Mexico. Development of the fishery has been slow and erratic, due to fluctuations in stock availability that affect commercial yield, and the lack of fully satisfactory meat-extracting equipment.

The research program at TABL provides information on the life history and ecology of the calico scallop necessary to recognize the factors that control abundance and distribution of harvestable stocks (Fig. 12). The program is coordinated with the NMFS Exploratory Fishing and Gear Research Base, Pascagoula, Miss., which studies the commercial abundance and availability of the scallops.

The Calico Scallop Biology program became fully functional at the beginning of FY 1970, although its inception was in FY 1969. Work began with a survey of the scientific literature concerning the biology and ecology of scallops, particularly calico scallops. Preliminary cruises were made in the fall and winter of 1969 to the calico scallop grounds off Cape Kennedy and Key West to observe the general environment inhabited by calico scallops. It became apparent that observations on scallops and their environment on a regular seasonal basis, at fixed sites, would be the most productive research method. For this reason, permanent study sites, in depths ranging from 6 to 12 fathoms, were established at five locations off Cape Kennedy (Fig. 13). Scallop beds exist near Buoys 1 and 2, but adult scallops are rare or absent at the remaining three sites. TABL personnel, trained as scuba divers, examined the bottom environments at Buoys 1 and 2. At Buoy 2, they installed a current meter, scallop enclosures, and other devices on the bottom, and made observations of marked scallops and associated organisms (Fig. 14).

During the 2 years in which the research program on calico scallops has been underway, a total of 17 cruises were made to the Cape Kennedy area: 9 cruises aboard the NMFS research vessels *Undaunted* and *George M. Bowers* and 8 cruises aboard chartered vessels. Some of the results of studies carried out on these cruises and in the laboratory follow.

Studies conducted on the Cape Kennedy grounds disclosed that calico scallops with ripe gonads were most abundant in the spring, declined in the late summer, and showed a moderate increase in the late fall. Comparison of ovarian color with a

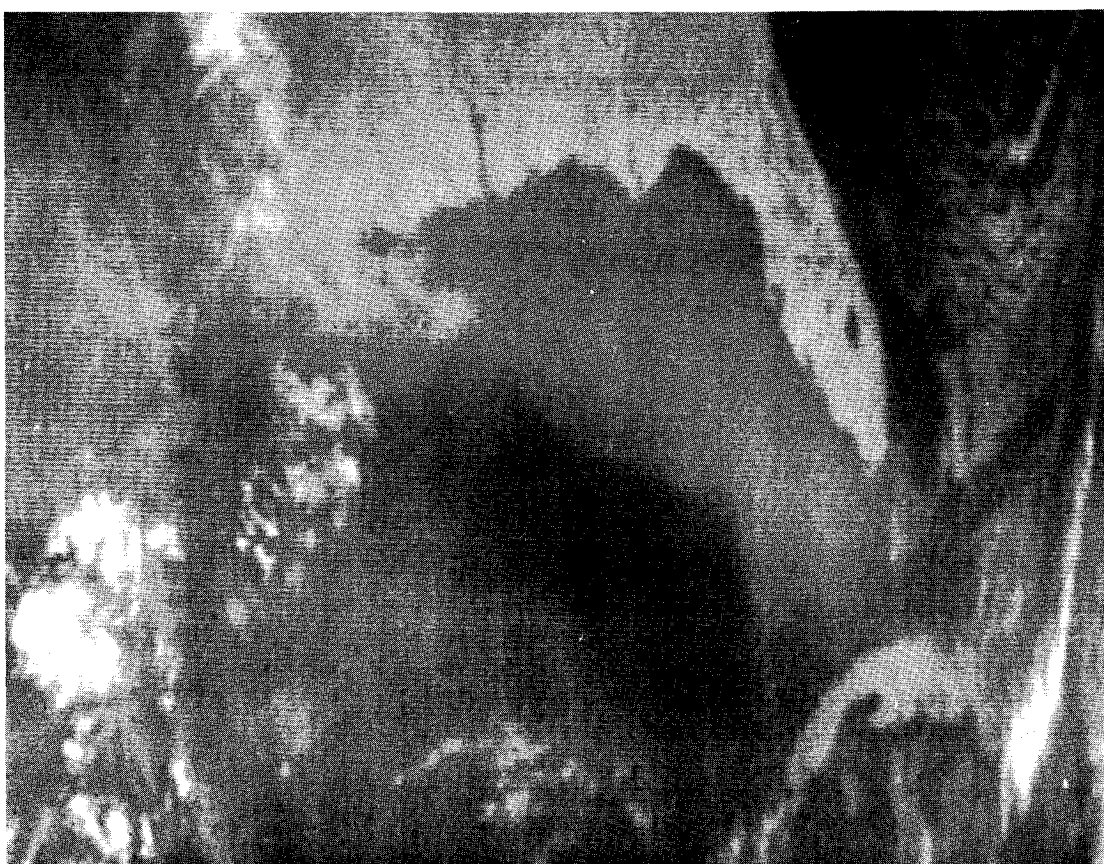

Figure 11. — Direct readout infra-red image of the Loop Current in the Gulf of Mexico. The image was received from the ITOS satellite on March 18, 1971.

Figure 12. An otter trawl filled with calico scallops is unloaded aboard the RV *George M. Bowers* on a recent TABL cruise. The wire net at the left of the picture is the chafing gear used to protect the trawl from damage as it is dragged along the ocean bottom.

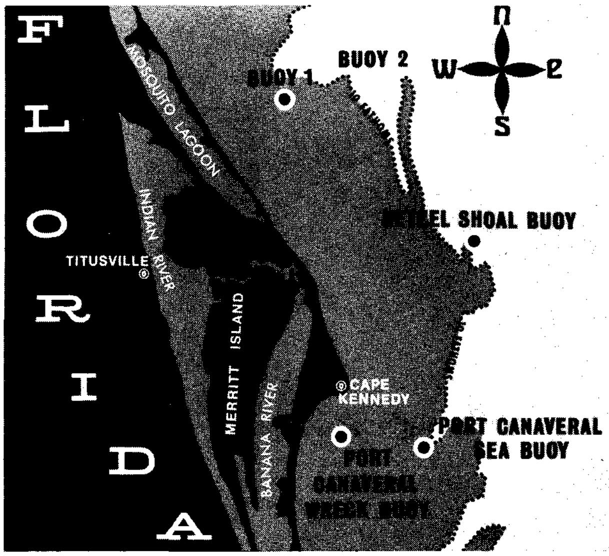

Figure 13. — This drawing shows the location of buoys 1 and 2 installed by the Calico Scallop program on scallop grounds near Cape Kennedy, Florida. Other buoys indicated by circles are permanent navigational guides.

known color standard, such as Pantone color specifier, was a good indicator of egg maturation. Ripe ovaries which contained 40 to 60 micron diameter mature ovocytes were vivid orange-red in color, and developing ovaries were light orange. Calico scallops as small as 19 mm in shell height sometimes had mature ovaries. Spent scallops retained a number of undeveloped eggs and sperm, indicating that individual animals may spawn more than once.

Spawning among calico scallops was induced in the laboratory by rapidly raising the water temperature in the holding tanks and by simultaneously introducing sperm solution. In one experiment the larvae survived 5 days to the veliger stage. The characteristics and development times of the larvae were observed. Later, larvae were reared at the Virginia Institute of Marine Science, where specialized facilities were available for rearing and photography. In this second experiment photomicrographs were made of the larvae and a complete series of larval stages was preserved. About 14 days elapsed between fertilization of the egg and settlement of the young scallops (spat), which were then about 0.25 mm in shell height. A number of the young scallops were returned from Virginia to TABL; these survived for more than 8 months and were used in a variety of experimental studies.

A method of monitoring the abundance and distribution of young scallops by spat collectors was developed. Field tests showed that young calico scallops would attach by byssal threads to a variety of artificial cultch materials. An effective spat collector now in use consists of a small nylon mesh bag stuffed with a standard quantity of polyethylene thread. The nylon mesh allows circulation of water but retains scallops after early growth. The traps, attached to anchored lines marked with surface buoys, were exposed at the five study sites on the Cape Kennedy grounds for varying periods of time throughout the year (Fig. 15). Spat setting (and, by deduction, spawning) occurred all year round, and intensity appeared greatest in the spring. The high intensity of spat setting in the spring correlates well with the high incidence of ripe scallops at the same time, and also with the large concentrations of seed scallops present on the fishing grounds in summer.

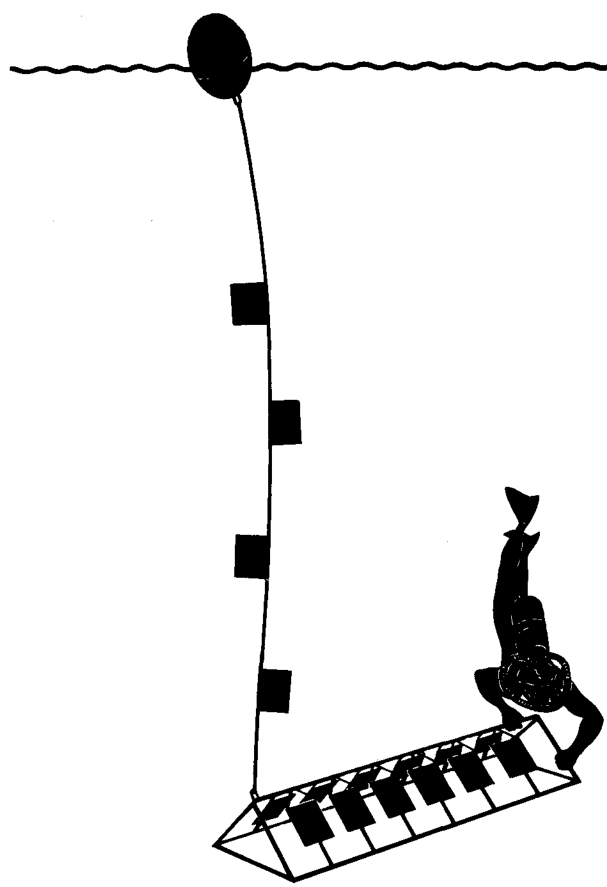

Figure 14. — An artist's concept of the calico scallop spat-monitoring array, with spat traps interspaced along a line in the water column and spat-collecting panels at the bottom. Scuba divers from TABL set such devices in place, monitor them at later dates, and collect samples from the bottom and the water column.

Figure 15. — Scuba divers from the TABL Calico Scallop program retrieve plastic spat collectors from a spat-monitoring array that has been used to "fish" for the tiny organisms in study plots near Cape Kennedy, Florida.

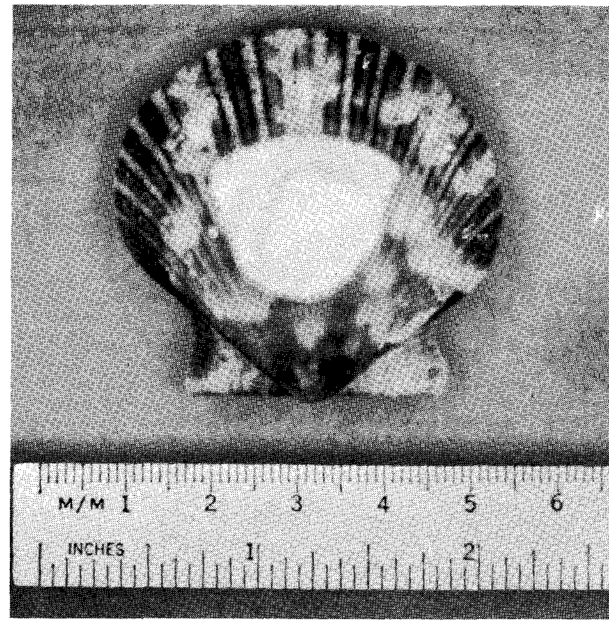

Figure 16. — A calico scallop marked with "All Crete" cement (white area in center of shell). Such marked scallops are placed on the scallop grounds and used as test animals to provide data on growth, movement, and mortality.

Study of the age and growth of calico scallops in their natural environment involves many complexities. Preliminary studies were designed to answer the following questions: (1) What is a suitable mark that can be applied rapidly to small and large scallops without killing them or harming their growth? (2) How does the growth of caged scallops compare with growth in the natural environment? (3) In what densities can scallops be held in cages? (4) What are the differences in mortality in cages of different mesh size? (5) For how long should a trawl net be fished to obtain an adequate sample from a single scallop bed?

An ideal mark for scallops was found in the industrial cement All-Crete[6] (Fig. 16), a compound which adheres to wet shell, can be placed in the water while wet, hardens rapidly, has no heat of hydration, is non-toxic, and can be colored for different marking codes.

The preliminary studies also showed that growth of scallops at the two study sites (Buoys 1 and 2) was comparable; growth of scallops in cages on the bottom was similar to growth of scallops on nearby natural beds; scallops could be held in minnow cages (1/2 cubic foot of water) at densities exceeding 1,000 newly set scallops (or fewer larger scallops); mortality increased as the mesh size of the cage was increased beyond 1/4 inch; and a 5-minute tow of a 10-foot try-net trawl, with a double tickler chain, usually provided an adequate sample from a single bed of scallops.

Studies of age and growth presently include: (1) obtaining the age-size relationship and the maximum age of calico scallops by following a known age group through its life cycle; (2) comparing the growth of scallops held in cages on the Cape Kennedy grounds with the length-frequency distribution of scallops from a nearby natural bed; (3) comparing the growth of laboratory-spawned scallops held in the warm-temperate region off Cape Kennedy with growth of siblings held in the tropical waters off Miami; (4) comparing the growth of various internal body parts with shell growth; and (5) determining if the number of external concentric rings of the shell can be correlated with age and changes in the environment.

An experiment to gather information on calico scallop behavior and movement was carried out off Miami in 21 feet of water on a clear, sandy bottom by members of the TABL diving unit. Scallops for the experiment were collected off Cape Kennedy. The divers laid out a precision grid, using 1-in. x 8-in. diameter numbered concrete discs placed at 2-meter intervals to form a 40-ft. x 60-ft. plot. A current meter monitored current speed and

6 Statement of product names is for identification purposes and does not imply endorsement by the National Marine Fisheries Service.

direction throughout the experiment. Bottom temperatures and salinities were also taken. Scallops placed in the center of the grid moved in a north-to-northwest direction, the general direction of current movement. Small scallops (20.2 to 40.2 mm shell height) moved more readily and farther than large scallops (50.0 to 70.5 mm shell height). On the Cape Kennedy grounds, TABL scuba divers observed that scallops about 40 mm in shell height swam as high as 3 feet off the bottom.

Organisms associated with calico scallops contribute to their mortality. Indications are that barnacle fouling may prevent complete closure of the valves and thus predators may be admitted. Mortality of scallops confined in large-mesh cages ranged from 40 to 100%, whereas in small-meshed cages it was less than 10%. That difference suggests that small mesh prevents entrance of certain predators. Divers observed that octopuses also may be predators of scallops confined in cages. During the course of the calico scallop movement experiment off Miami, described above, divers observed that a resident population of shamefaced crabs, *Calappa flammea*, caused considerable mortality to the scallops. This crab previously was unknown as a calico scallop predator. There are at least three species of shamefaced crabs on the scallop beds off Cape Kennedy, including *C. flammea*. Further study on this predator is now underway.

Distribution, abundance, and growth of calico scallops probably are strongly influenced by water temperature, current, bottom type, food availability, and associated organisms. Research on the physical environment of the Cape Kennedy scallop grounds has been restricted to monitoring water temperature, transparency, salinity, and current. Recording thermographs operate at Buoys 1 and 2.

Observations show distinct differences between the environments at each study site. For example, at Hetzel Shoal Buoy the bottom temperatures most of the year are typically lower than at the remaining study sites; at Port Canaveral Wreck Buoy, the water is always more turbid than at the the other sites.

A major environmental change took place on the Cape Kennedy grounds during the period from May 26 to June 26, 1971. Cold water (15°C) intruded onto the shelf to as shallow a depth as 20 fathoms. Scallops, modally 32 mm, on the natural bed near Buoy 2 showed no growth during the month. The growth of small scallops held in cages at Buoy 2 was significantly less than that of siblings held at inshore Buoy 1. Small scallops that had set in the cages at Buoy 2 were significantly fewer than those found in cages at Buoy 1. Mortality of large scallops at the study sites was normal and not excessive. Cold water intrusions, with rapid temperature drops of 10°C, could cause drastic mortalities of very small juveniles at the peak of the spawning season and a vast fluctuation in the scallop population.

Affiliated Projects

During the period of this report TABL housed an interesting assortment of tenants, most of whom performed tasks under the direction of other agencies. Some of these worked independently of TABL personnel, merely sharing physical facilities; others required or requested cooperation and advice from either laboratory management or individuals. A brief explanation of some of these diversified activities carried on under the TABL roof follows.

1. In mid-1969, as a result of a joint agreement between the Department of Commerce and Interior's Bureau of Indian Affairs, space was made available at TABL to conduct a 2-year feasibility study of the rearing of freshwater shrimp (*Macrobrachium*) in Florida. The objective of the project is to help the Seminole Indians of the Florida Everglades to establish a new industry based on extensive aquaculture and marketing of the species. The chief of TABL's Calico Scallop program helped draw up the original design for the experiment, and functioned as scientific adviser to the program. Office and aquarium-room space were occupied by members of the freshwater shrimp program, and laboratory tanks, scientific equipment, and other facilities were used to rear and maintain these large crustaceans.

2. The Interior Department's South Florida Environmental Project has been headquartered in a three-room suite at TABL since June 1970. The project, which is under the direct supervision of the Secretary of the Interior, is presently charged with the thorny problem of recommending and approving the site to be selected for a South Florida jetport, within the limitations imposed by protection of the natural environment. The Interior project also is responsible for the environmental monitoring of the present jet-training site in Big Cypress Swamp (part of the Everglades). This diversified ecological survey proposes to delineate the resources within the swamp itself that merit preservation and protection, to study the interrelation-

ship of the swamp to the ecosystems of Everglades National Park, to define the correlation of the swamp with water needs of South Florida communities, and to analyze the marine resources of the estuaries dependent upon the swamp. A senior scientist on the TABL staff worked closely with the Project staff to represent NMFS interests.

3. A team of scientists from the Federal Water Quality Administration laboratory at Narragansett, R.I., occupied office and laboratory space while completing an intensive study of the survival of plankton organisms that had passed through the turbines of an electric generating plant.

4. Professors from several colleges spent the summer months of 1970 and 1971 working at TABL on programs supported by the National Science Foundation, under the Research Participation Program. The program is prosecuted jointly by the University of Miami and TABL, and is directed by TABL's assistant director. Colleges and universities represented were: Carson Newman College (Tenn.), Louisiana State College, Muskingum College (Ohio), the New York Institute of Technology, Southern Connecticut State College, and the University of Massachusetts. Investigations pursued by the visiting scientists involved: variations in the taxonomy of microalgae from the Straits of Florida and Biscayne Bay; a large-scale revisionary study of the sciaenids of the Caribbean and western South American coast; remote sensing by satellites of oceanographic indicators of fish populations; determinations of temperature requirements and of food levels necessary to maintain growth and guarantee survival of larval fish in aquariums; and immune responses in shrimp and crabs. The visiting investigators worked under the direction of TABL scientists.

Professional Staff

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Publications[7]

ALLEN, DONALD M.
1971. Progress in studies of the calico scallop. (Abstract.) Proc. Natl. Shellfish. Assoc. 61:1. TABL 183.
———, and J. HAROLD HUDSON.
1970. A sled-mounted suction sampler for benthic organisms. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 614, 5 pp. TABL 150.
ANDERSON, WILLIAM D., JR.
1970. Revision of the genus *Symphysanodon* (Pisces: Lutjanidae) with descriptions of four new species. Fish. Bull. 68(2): 325-346. TABL 153.
BEARDSLEY, GRANT L., JR.
1969. Proposed migrations of albacore, *Thunnus alalunga*, in the Atlantic Ocean. Trans. Amer. Fish. Soc. 98(4): 589-598. TABL 109.

[7]Names of authors who are not members of the Miami Laboratory staff are shown in lower case letters.

1970. Distribution of migrating juvenile pink shrimp, *Penaeus duorarum duorarum* Burkenroad, in Buttonwood Canal, Everglades National Park, Florida. Trans. Amer. Fish. Soc. 99(2): 401-408. TABL 88.

1970. The Atlantic albacore fishery. Commer. Fish. Rev. 32(6): 41-45. TABL 155.

————, and WILLIAM J. RICHARDS.

1970. Size, seasonal abundance, and length-weight relation of some scombrid fishes from southeast Florida. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 595, 6 pp. TABL 148.

BERRY, FREDERICK H.

1969. *Elagatis bipinnulata* (Pisces: Carangidae): Morphology of the fins and other characters. Copeia 1969(3): 454-463. TABL 81.

1969. Taxonomic status of western Atlantic clupeid fishes. (Abstract.) FAO Fish. Rep. 71.1: 146. TABL 159.

Iversen, E. S., and FREDERICK H. BERRY.

1969. Fish mariculture: Progress and potential. Proc. Gulf Carib. Fish. Inst., 21st Annu. Sess., pp. 163-176. TABL 115.

BORKOWSKI, MARILYNN R., and
JULIEN R. GOULET, JR.

1971. Comparison of methods for interpolating oceanographic data. Deep Sea Res. 18: 269-274. TABL 171.

BRUCKS, JOHN T.

1969. The current east of the Windward Islands, West Indies. (Abstract.) FAO Fish. Rep. 71:1: 103. TABL 158.

COSTELLO, T.J.

1971. Rearing marine and freshwater shrimp in Florida. (Abstract.) Quart. J. Fla. Acad. Sci. 34 (suppl. 1): 19-20.

1971. Fresh water prawn culture techniques developed. Amer. Fish Farmer and World Aquaculture News, p. 8-10, 27. TABL 181.

Maughan, Paul M., and BENJAMIN J. CULVERHOUSE.

1970. Satellite automatic picture transmission system used aboard fishery research vessel. Ocean Ind. 5(10): 45-46. TABL 137.

DALY, RICHARD J.

1970. Systematics of southern Florida anchovies (Pisces: Engraulidae). Bull. Mar. Sci. 20(1): 70-104. TABL 103.

DRAGOVICH, ALEXANDER.

1969. Dinoflagellates. *In*: Frank E. Firth (editor), Encyclopedia of marine resources, pp. 169-177. Van Nostrand Reinhold Co., N.Y. TABL 57.

1969. Review of studies of tuna food in the Atlantic Ocean. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 593, 21 pp. TABL 117.

1969. Observations on the food of skipjack tuna in the eastern Caribbean. (Abstract.) FAO Fish. Rep. 71:1: 144-145. TABL 162.

1970. The food of bluefin tuna (*Thunnus thynnus*) in the western North Atlantic Ocean. Trans. Amer. Fish. Soc. 99(4): 726-731. TABL 151.

1970. The food of skipjack and yellowfin tunas in the Atlantic Ocean. Fish. Bull. 68(3): 445-460. TABL 165.

————, and JOHN P. WISE.

1969. Relations between length of the pen and other measurements in the squid *Lolliguncula brevis*. J. Fish. Res. Bd. Can. 26(6): 1676-1679. TABL 111.

FOX, WILLIAM W.

1970. An exponential surplus-yield model for optimizing exploited fish populations. Trans. Amer. Fish. Soc. 99(1): 80-88. TABL 123.

Detwyler, Robert, and EDWARD D. HOUDE.

1970. Food selection by laboratory-reared larvae of the scaled sardine *Harengula pensacolae* (Pisces, Clupeidae) and the bay anchovy *Anchoa mitchilli* (Pisces, Engraulidae). Mar. Biol. 7(3): 214-222. TABL 170.

HUDSON, J. HAROLD.

1971. The calico scallop: fishery and research developments. Amer. Malacol. Union Annu. Rep. Bull. for 1970, pp. 27-28. TABL 182.

INGHAM, MERTON C.

1970. Coastal upwelling in the northwestern Gulf of Guinea. Bull. Mar. Sci. 20(1): 1-34. TABL 121.

1970. Wind and sea-surface temperature off Mauritania-Sierra Leone. Mar. Technol. Soc. J. 4(4): 55-57. TABL 154.

IWAMOTO, TOMIO.

1970. Macrourid fishes of the Gulf of Guinea. Studies Trop. Oceanogr. No. 4(Pt. 2): 316-431. TABL 106.

JONES, ALBERT C.

1969. Tropical Atlantic tuna investigations, 1968. Proc. Gulf Carib. Fish. Inst., 21st Annu. Sess., pp. 76-85. TABL 108.

————, Dolores E. Dimitriou, Joseph J. Ewald, and John H. Tweedy.

1970. Distribution of early developmental stages of pink shrimp, *Penaeus duorarum*, in Florida waters. Bull. Mar. Sci. 20(3): 634-661. TABL 172.

Roessler, Martin A., ALBERT C. JONES, and
John L. Munro.

1970. Studies of larval and postlarval pink shrimp, *Penaeus duorarum*, in South Florida. Proc. FAO World Shrimp Congress (1967). TABL 142.

GOULET, JULIEN R., JR.

1969. Currents off the eastern bulge of Brazil - a preliminary report. (Abstract.) FAO Fish. Rep. 71.1: 103. TABL 160.

1970. Temperature and salinity characteristics of the ocean adjacent to the northeast "bulge" of Brazil. (Abstract.) *In*: Abstracts of papers submitted for the Thirty-Third Annual Meeting, Amer. Soc. Limn. Oceanogr., Kingston, R.I. 1970, p. 13. TABL 177.

1971. Root-mean-squares of temperature and salinity gradients. (Abstract.) Trans. Amer. Geophy. U. 52(4): 232.

Maughan, Paul M., MERTON C. INGHAM, and
J. FRANK HEBARD.

1969. Feasibility of monitoring west African oceanic front from satellites. Commer. Fish. Rev. 31(10): 24-29. TABL 112.

HOUDE, EDWARD D.

1970. Effect of *Chlorella* on successful rearing of marine fish larvae. FAO Fish Culture Bull. 2(4): 3. TABL 168.

————, and WILLIAM J. RICHARDS.

1969. Rearing larval tunas in the laboratory. Commer. Fish. Rev. 31(12): 32-34. TABL 130.

————, and BARBARA J. PALKO.

1970. Laboratory rearing of the clupeid fish *Harengula pensacolae* from fertilized eggs. Mar. Biol. 5(4): 354-358. TABL 149.

————, Charles R. Futch, and Robert Detwyler.

1970. Development of the lined sole, *Achirus lineatus*, described from laboratory-reared and Tampa Bay

specimens. Fla. Dept. Nat. Res. Tech. Ser. 62, 43 pp. TABL 173.

JOSSI, JACK W.

1970. Annotated bibliography of zooplankton sampling devices. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 609, 90 pp. TABL 104.

Aron, William I., JACK W. JOSSI, and Richard E. Pieper.

1970. Bio-acoustic and biological sampling gear studies. Smithsonian Inst. Rep. 7122, 83 pp. (available from Defense Documentation Center, Cameron Station, Alexandria, Va., 22314, Report No. AD 707085). TABL 174.

LEMING, T.D.

1969. Eddies west of the southern Lesser Antilles. (Abstract.) FAO Fish. Rep. 71.1: 102. TABL 161.

MAHNKEN, CONRAD V. W.

1969. Primary organic production and standing stock of zooplankton in the tropical Atlantic Ocean — EQUALANT I and II. Bull. Mar. Sci. 19(3): 550-567. TABL 60.

McCABE, MEAD M., and DAVE M. DEAN.

1970. Esterase polymorphism in the skipjack tuna, *Katsuwonus pelamis*. Comp. Biochem. Physiol. 34: 671-681. TABL 178.

MILLER, GEORGE C.

1969. A revision of the zoogeographical regions in the warm-water area of the western Atlantic. (Abstract.) FAO Fish. Rep. 71.1: 141. TABL 119.

1971. Commercial fishery and biology of the fresh-water shrimp, *Macrobrachium*, in the lower St. Paul River, Liberia, 1952-53. Spec. Sci. Rep. Fish. 626, 13 pp. TABL 141.

——————, and Jack M. Van Hyning.

1970. The commercial fishery for fresh-water crawfish, *Pacifastacus leniusculus* (Astacidae), in Oregon, 1893-1956. Fish Comm. of Oregon Res. Rep. 2(1): 77-89. TABL 126.

MILLER, ROBERT V.

1969. Continental migrations of fishes. Underwater Natur. 3(1): 15-23, 44. TABL 99.

1971. A new sciaenid fish with a single mental barbel. Copeia 1971(2): 300-306. TABL 167.

——————, and JOHN VAN LANDINGHAM.

1969. Additional procedures for effective enzyme clearing and staining of fishes. Copeia 1969(4): 829-830. TABL 110.

Bertmar, Gunnar B., G. Kapoor, and ROBERT V. MILLER.

1969. Epibranchial organs in lower Teleostean fishes — an example of structural adaptation. Int. Rev. Gen. Exper. Zool. 4: 1-48. TABL 76.

PALKO, BARBARA J., and WILLIAM J. RICHARDS.

1969. The rearing of cowfish and related species from eggs. Salt Water Aquarium 5(3): 67-70. TABL 102.

POTTHOFF, THOMAS C.

1969. Searching for tuna. Commer. Fish. Rev. 31(7): 35-37. TABL 124.

——————, and WILLIAM J. RICHARDS.

1970. Juvenile bluefin tuna, *Thunnus thynnus* (Linnaeus), and other scombrids taken by terns in the Dry Tortugas, Florida. Bull. Mar. Sci. 20(2): 389-413. TABL 85.

RICHARDS, WILLIAM J.

1969. Distribution and relative apparent abundance of larval tunas collected in the tropical Atlantic during EQUALANT surveys I and II. Proc. Symp. Oceanogr. Fish. Resourc. Trop. Atl., Rev. Papers. Contrib., UNESCO, Paris, pp. 289-315. TABL 37.

1969. Elopoid leptocephali from Angolan waters. Copeia 1969(3): 515-518. TABL 97.

1969. Tropical Atlantic tuna larvae collected during the EQUALANT surveys. Commer. Fish. Rev. 31(11): 33-37. TABL 133.

1969. An hypothesis on yellowfin tuna migrations in the eastern Gulf of Guinea. Cah. ORSTOM 7(3): 3-7. TABL 95.

——————, and G. R. DOVE.

1971. Internal development of young tunas of the genera *Katsuwonus*, *Euthynnus*, *Auxis*, and *Thunnus* (Pisces, Scombridae). Copeia 1971(1): 72-78. TABL 156.

——————, and BARBARA J. PALKO.

1969. Methods used to rear the thread herring, *Opisthonema oglinum*, from fertilized eggs. Trans. Amer. Fish. Soc. 98(3): 527-529. TABL 98.

——————, and J. P. WISE.

1969. The biology and fisheries of large scombroid fishes off north-west Africa. (Abstract.) Proc. Symp. Living Resourc. Afr. Atl. Cont. Shelf between the Straits of Gibraltar and Cape Verde. FAO Fish. Rep. 68, p. 50. TABL 75.

——————, DAVID C. SIMMONS, ANN JENSEN, and WALTER C. MANN.

1969. Tuna larvae (Pisces, Scombridae) collected in the northwestern Gulf of Guinea, GERONIMO cruise 3, 10 February to 26 April 1964. U.S. Fish Wildl. Serv., Data Rep. 36, 19 pp. on 1 microfiche. TABL 100.

——————, DAVID C. SIMMONS, ANN JENSEN, and WALTER C. MANN.

1969. Larvae of tuna and frigate mackerel (Pisces, Scombridae) collected in the northwestern Gulf of Guinea, GERONIMO cruise 4, 5 August to 13 October 1964. U.S. Fish Wildl. Serv., Data Rep. 37, 17 pp. on 1 microfiche. TABL 114.

——————, DAVID C. SIMMONS, ANN JENSEN, and WALTER C. MANN.

1970. Larvae of tuna and frigate mackerel (Pisces, Scombridae) in the northwestern Gulf of Guinea and off Sierra Leone, GERONIMO cruise 5, 10 February to 19 April 1965. U.S. Fish Wildl. Serv., Data Rep. 40, 24 pp. on 1 microfiche. TABL 118.

Matsumoto, Walter M., S. Jones, Witold L. Klawe, WILLIAM J. RICHARDS, and Shoji Ueyanagi.

1969. Report of the working party on tuna eggs, larvae, and juveniles. *In*: Report of the Third Session of the FAO Panel of Experts for the Facilitation of Tuna Research. FAO Fish. Rep. 60, pp. 20-33. TABL 187.

SINDERMANN, CARL J.

1970. The role and control of diseases and parasites in mariculture. *In*: Proc. Food and Drugs from the Sea, 1969, pp. 145-173. TABL 134.

1970. Principal diseases of marine fish and shellfish. Academic Press, N.Y., 369 pp.

1970. Diseases of marine fishes. T.F.H. Publications, Jersey City, N.J., 89 pp. (paperback).

1970. Diseases of marine animals transmissible to man. Lab. Med. 1(1): 50-54. TABL 135.

1970. Disease and parasite problems in marine aquiculture. *In*: "Marine Aquiculture" (W. J. McNeil, Ed.), pp. 103-134. Ore. St. Univ. Press, Corvallis, Ore. TABL 140.

1971. Predators and diseases of commercial marine Mollusca of the United States. (Abstract.) Amer. Malacol. Union Annu. Rep. Bull. for 1970, pp. 35-36. TABL 179.

Villella, J. B., E. S. Iversen, and C. J. SINDERMANN.

1970. Comparison of the parasites of pond-reared and wild pink shrimp (*Penaeus duorarum* Burkenroad) in south Florida. Trans. Amer. Fish. Soc. 99(4): 789-794. TABL 176.

SMITH, DAVID G.

1970. Nocanthiform leptocephali in the western North Atlantic. Copeia 1970(1): 1-9. TABL 84.

1970. The correct identify of two "rare" Hawaiian eels. Copeia 1970(2): 366-367. TABL 122.

TASHIRO, JOSEPH E., and JAMES F. HEBARD.

1969. A modification of the plankton volume gauge for use aboard ship. Limnol. Oceanogr. 14(5): 794-796. TABL 116.

WEEKS, ANN.

1970. Progress in research, Tropical Atlantic Biological Laboratory, Miami, Florida, 1965-69. U.S. Fish Wildl. Serv. Circ. 344, 65 pp. TABL 147.

1970. Miami scientists study Florida calico scallops. Commer. Fish. Rev. 32(5): 11-13. TABL 152.

WILSON, PETER C., and James S. Beckett.

1970. Atlantic Ocean distribution of the pelagic stingray, *Dasyatis violacea*. Copeia 1970(4): 696-707. TABL 125.

WISE, JOHN P.

1969. Tuna purse seine fishery in eastern tropical Atlantic. Commer. Fish. Rev. 31(11): 27-28. TABL 136.

——————, and W. W. FOX, JR.

1969. Dynamics of the yellowfin tuna fishery of the Caribbean region. (Abstract.) FAO Fish. Rep. 71.1: 142. TABL 163.

——————, and ALBERT C. JONES.

1969. Tunas and tuna fisheries of the Caribbean region. (Abstract.) FAO Fish. Rep. 71.1: 142. TABL 164.

——————, and Jean Claude Le Guen.

1969. The Japanese Atlantic longline fishery, 1956-1963. Proc. Symp. Oceanogr. Fish. Resourc. Trop. Atl. Rev. Papers Contrib., UNESCO, Paris, pp. 317-347. TABL 35.

Crosnier, A., A. Fontana, J. C. Le Guen, and J. P. WISE.

1970. Ponte et croissance de la crevette pénéide *Parapenaeus longirostris* (Lucas) dans la région de Pointe-Noire (République du Congo). Cahiers ORSTOM Série Océanographie 8(4), 89-102. TABL 190.

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